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MULTI-BAND ANTENNA

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to an antenna, and in particular to an antenna which is capable of operating in multiple frequency bands.

2. Description of the Prior Art

[0002] In recent years, planar inverted-F antennas (PIFA) have become increasingly popular. A paper titled "Dual-Frequency PIFA", Microstrip Antenna Design Handbook by Ramesh Garg et al, 2001, Section 10.9.3, pp. 646-653 discloses a conventional antenna shown in Figure 10.45 thereof. The conventional antenna comprises two separate radiating elements spaced to each other by an L-shaped gap. Each radiating element has a feed pin and a ground pin of its own, thereby forming an independent PIFA. The radiating elements constitute independent regions having different resonant frequencies. However, because each radiating element must have a feed pin and a ground pin of its own, the conventional antenna has a complicated structure.

[0003] Hence, an improved antenna is desired to overcome the above-mentioned shortcomings of existing antennas.

BRIEF SUMMARY OF THE INVENTION

[0004] A main object of the present invention is to provide a multi-band antenna having a simple structure while maintaining a wide-bandwidth characteristic.

[0005] A multi-band antenna in accordance with the present invention comprises an insulative substrate carrying a conductive element and a coaxial cable. The conductive element comprises a first radiating patch and a second radiating

patch. The first radiating patch is spaced from the second radiating patch by a non-conductive gap. The coaxial cable comprises an inner conductor and an outer conductor. The inner conductor electrically connects with the first radiating patch. The outer conductor electrically connects with the second radiating patch. When the multi-band antenna is fed first frequency band signals, the first radiating patch resonates at the first frequency band signals and capacitively couples to the second radiating patch. The second radiating patch functions as a grounding means for the first radiating patch. When the multi-band antenna is fed second frequency band signals, the second radiating patch resonates at the second frequency band and capacitively couples to the first radiating patch. The first radiating patch functions as a grounding means for the second radiating patch.

[0006] In the present invention, the first and the second radiating patches resonate respectively at different frequency bands and function as grounding means for each other. The single feed line feeds signals for both of the first and the second radiating patches. The multi-band antenna, therefore, has a simple structure while maintains its wide-bandwidth characteristic.

[0007] Other objects, advantages and novel features of the invention will become more apparent from the following detailed description of a preferred embodiment when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Fig. 1 is a top view of a multi-band antenna in accordance with the present invention;

[0009] Fig. 2 is a side view of the multi-band antenna of Fig. 1 with a feed line thereof removed;

[0010] Fig. 3 is a perspective view of an electrical device, showing locations

of a pair of multi-band antennas of Fig. 1 mounted therein;

[0011] Fig. 4 is a test chart recording for the multi-band antenna of Fig. 1, showing Voltage Standing Wave Ratio (VSWR) as a function of frequency;

[0012] Fig. 5 is a horizontally polarized principle plane radiation pattern (where the principle plane is an X-Y plane) of the multi-band antenna of Fig. 1 operating at a frequency of 2.49 GHz;

[0013] Fig. 6 is a vertically polarized principle plane radiation pattern (where the principle plane is an X-Y plane) of the multi-band antenna of Fig. 1 operating at a frequency of 2.49 GHz;

[0014] Fig. 7 is a horizontally polarized principle plane radiation pattern (where the principle plane is an X-Y plane) of the multi-band antenna of Fig. 1 operating at a frequency of 5.35 GHz;

[0015] Fig. 8 is a vertically polarized principle plane radiation pattern (where the principle plane is an X-Y plane) of the multi-band antenna of Fig. 1 operating at a frequency of 5.35 GHz;

[0016] Fig. 9 is a horizontally polarized principle plane radiation pattern (where the principle plane is an X-Y plane) of the multi-band antenna of Fig. 1 operating at a frequency of 5.9 GHz; and

[0017] Fig. 10 is a vertically polarized principle plane radiation pattern (where the principle plane is an X-Y plane) of the multi-band antenna of Fig. 1 operating at a frequency of 5.9 GHz.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Reference will now be made in detail to a preferred embodiment of the present invention.

[0019] Referring to Figs. 1 and 2, a multi-band antenna in accordance with a preferred embodiment of the present invention comprises an insulative substrate 1,

a conductive element 2 carried by the insulative substrate 1 and a feed line 3 electrically connecting with the conductive element 2.

[0020] The insulative substrate 1 is substantially rectangular and comprises a planar major surface (not labeled) carrying the conductive element 2. The conductive element 2 has a substantially rectangular configuration confined by a substantially continuous border line. A non-conductive gap 21 divides the conductive element 2 into a first radiating patch 22 resonating at a higher frequency band and a second radiating patch 23 resonating at a lower frequency band. The non-conductive gap 21 has a substantially T-like configuration and comprises a horizontal first branch 211, a perpendicular second branch 212 and a horizontal third branch 213. The first branch 211 comprises an outer end (not labeled) arranged on a left edge of the conductive element 2. The third branch 213 extends into the second radiating patch 23 from a junction of the first and the second braches 211 and 212. The first radiating patch 22 is rectangular and is parallelly spaced from the second radiating patch 23 by the first and the second branches 211 and 212. The second radiating patch 23 has a substantially inverted J-like configuration and surrounds two sides of the first radiating patch 22. The first radiating patch 22 comprises a first excitation point 221 thereon. The second radiating patch 23 comprises a second excitation point 231 thereon. The first and the second excitation points 221 and 231 are adjacent to the outer end of the first branch 211 of the non-conductive gap 21.

[0021] The feed line 3, in this preferred embodiment, is a coaxial cable comprising an inner conductor 31, an inner insulator (not shown) surrounding the inner conductor 31 and an outer conductor 32 surrounding the inner insulator. The inner conductor 31 is soldered to the first excitation point 221 of the first radiating patch 22. The outer conductor 32 is soldered to the second excitation point 231 of the second radiating patch 23.

[0022] In present invention, by adjusting the lengths of the first and the second radiating patches 22 and 23, operating frequencies of the multi-band antenna can be changed. By adjusting the width and length of the non-conductive gap 21, the bandwidth of the multi-band antenna can be adjusted. By adjusting the distance of the excitation points 221 and 231 from the left edge of the conductive element 2, the impedance matching and Voltage Standing Wave Ratio (VSWR) can be improved. Detailed dimensions of the preferred embodiment of the multi-band antenna are shown in Fig. 1. The dimensions are in millimeters and are such that the multi-band antenna is configured to resonate within the two frequency bands. When the multi-band antenna is fed the higher frequency band signals between 4.9 GHz and 5.9 GHz (i.e., the 5 GHz frequency band), the first radiating patch 22 resonates at the higher frequency band signals and capacitivly couples to the second radiating patch 23 via the first and the second branches 211, 212. The second radiating patch 23 functions as a grounding plane for the first radiating patch 22. The first radiating patch 22, therefore, is configured and sized to function as a first planar inverted-F antenna (PIFA). When the multi-band antenna is fed the lower frequency band signals between 2.39 GHz and 2.49 GHz (i.e., the 2.45 GHz frequency band), the second radiating patch 23 resonates at the lower frequency band signals and capacitively couples to the first radiating patch 22. The first radiating patch 22 functions as a grounding plane for the second radiating patch 23. The second radiating patch 23, therefore, is configured and sized to function as a second PIFA.

[0023] The antenna performance was measured in Anechoic Chamber. The multi-band antenna was located inside the electrical device, a notebook panel in this embodiment, during measurement. Fig.3 shows a pair of the multi-band antennas is symmetrically mounted in chambers above a Liquid Crystal Display (LCD) of the notebook. Fig. 4 shows a test chart recording of VSWR of the

multi-band antenna as a function of frequency. The antenna operation bandwidth is usually defined by VSWR$\leq$2.0. Note that VSWR drops below the desirable maximum value "2" in the 2.45 GHz frequency band and in the 5 GHz frequency band, i.e., the operation bandwidth of the multi-band antenna covers 2.39-2.49GHz and 4.9-5.9GHz, indicating acceptably efficient operation in these two frequency bands and a wide bandwidth in the 5 GHz frequency band.

[0024] Figs. 5-10 respectively show horizontally and vertically polarized principle plane radiation patterns of the multi-band antenna operating at frequencies of 2.49 GHz, 5.35 GHz and 5.9 GHz (the principle plane is the X-Y plane shown in Fig. 1). Note that each radiation pattern is close to a corresponding optimal radiation pattern.

[0025] It is to be understood, however, that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.